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BOARD-FOOT INCREMENT ON RESIDUAL PONDEROSA PINE IN MONTANA

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In the partial cutting of forest stands, growth of the residual trees is an important management consideration. A cooperative study[1] established in 1932 in the Blackfoot Valley in western Montana relates growth to three different levels of reserve in mature ponderosa pine. The stands originally contained from 15,000 to 20,000 board feet per acre on Site Index 70. Twenty-year records disclose that 4,000 to 8,000 board feet per acre of vigorous, well-spaced trees, between 120 and 220 years old and of moderate size comprised a satisfactory reserve.

METHODS

A virgin ponderosa pine stand on Site Index 70 (age 100) was chosen for study. Three contiguous plots of 4 to 7 acres each were given different cutting treatments. The cuttings were called locally, according to prevailing practice in 1932, a "clear cutting," an "intensive-silvicultural selection cutting," and an "economic" or "zero-margin cutting."[2] The stated objectives were to compare between cuttings the immediate margin of profit and the subsequent growth. The basis for choosing the cut and leave trees, therefore, was somewhat different than if regeneration had been the foremost goal. Each resulted in removing different amounts of sawtimber and will be called in this report heavy, medium, and light cuttings, respectively.

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[1] Cooperators were the Montana State Department of Forestry; School of Forestry, Montana State University; Lumber Department, The Anaconda Company; Northern Region, U. S. Forest Service; and the Northern Rocky Mountain Forest and Experiment Station which was consolidated in 1953 with the Intermountain Forest and Range Experiment Station.

[2] Anderson, I. V. Application of selective logging to a ponderosa pine operation in western Montana. State University of Montana Studies 2, 56 pp. Missoula. 1934.

The heavy cutting removed virtually all ponderosa pine and Douglas-fir trees of the then minimum merchantable diameter of 14 inches, and larger. On the medium cutting, vigorous, high-quality ponderosa pine having the greatest growth potential were reserved. The light cutting removed only high-quality ponderosa pines 14 inches in diameter and larger. Furthermore, in this cutting only those logs whose lumber selling value exceeded production costs were removed from the woods. Stand volumes before and after cutting and the volume cut by each intensity are shown in table 1.

Following cutting, all trees 4 inches d.b.h. and larger were tagged and measured at 5-year intervals. Trees subsequently reaching the 4-inch diameter class were tagged and measured in 1947 and 1952.

RESULTS

Growth of Residual Stands

Board-foot volume accrual on the 120- to 220-year-old sawtimber reserve was similar to that reported from other ponderosa pine studies in western Montana.[3,4] Periodic annual growth on reserve trees increased substantially in the second 5-year period after cutting and tended to culminate during the third or fourth period (figure 1).

The 20-year increment of each reserve stand varied directly with residual volume. On the heavy cutting gross growth totaled 954 board feet on a reserve of 2,018; on the medium cutting, 1,948 on a reserve of 4,150; and on the light cutting, 2,362 on a reserve of 10,004 board feet. Percentage-wise, gross growth on the light cutting was 24 percent of the reserve volume for the 20-year period or about one-half of the percentage increases on the heavy and medium cuttings. These percentage differences reflect the multiple effects of reserve volume, tree size, age, vigor, and growing space.

3/ Roe, Arthur L. What is the right cutting cycle for ponderosa pine? North. Rocky Mtn. Forest and Range Expt. Sta. Res. Note 57, 3 pp. 1947.

4/ Roe, Arthur L. Growth of selectively cut ponderosa pine stands in the Upper Columbia Basin. Agr. Handb. 39, 28 pp. 1952.

Table 1.--Initial, cut, and reserve volumes per acre

Intensity of cutting	Initial volume			Cut volume			Reserve volume		
	Ponderosa pine	Douglas-fir	Total	Ponderosa pine	Douglas-fir	Total	Ponderosa pine	Douglas-fir	Total
	Board feet			Board feet			Board feet		
Heavy (90 percent)	16,268	3,042	19,310	15,451	1,841	17,292	817	1,201	2,018
Medium (78 percent)	13,690	5,428	19,118	10,404	4,564	14,968	3,286	864	4,150
Light (41 percent)	12,094	4,846	16,940	6,615	321	6,936	5,479	4,525	10,004

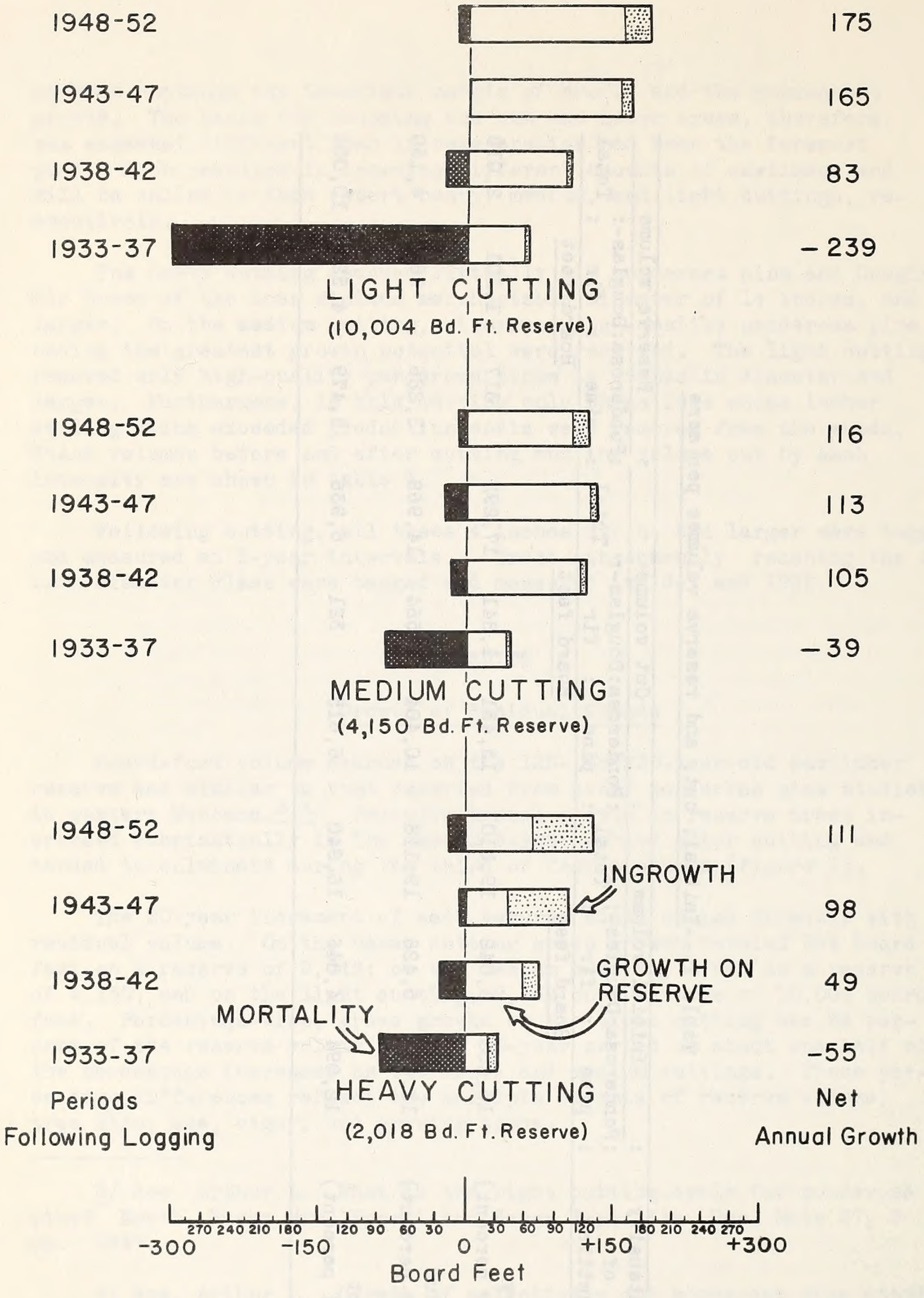

Figure 1 – Periodic Annual Board Foot Growth Per Acre

Following Three Intensities Of Cutting.

Losses in merchantable volume on all cuttings culminated during the first 5-year period after logging, then decreased to small annual amounts during the other three periods (figure 1). On the light cutting the annual loss of 300 board feet per acre during the first period surpassed by more than three times the losses suffered on the other two cuttings. Insects accounted for more than 90 percent of this large mortality. Apparently bark beetles multiplied rapidly in large-sized cull material left on the ground in the light cutting, then attacked and killed living trees.[5/] About 70 percent of the volume losses on the heavy cutting and only 24 percent on the medium cutting were caused by insects. On the other hand, wind accounted for 59 percent of the losses on the medium cutting in the first period. During the other three 5-year periods, wind caused about 50 percent of the losses on each of the cuttings.

Ingrowth contributed a large part of the total growth on the heavy cutting but negligible amounts on the other cuttings (figure 1). The differences between the amounts of ingrowth are due primarily to the greater number of near-merchantable trees in the residual stand on the heavy cutting plus the faster growth per tree associated with more growing space.

Periodic net annual growth paralleled the growth on reserve stands plus ingrowth during the last three 5-year periods after logging (figure 1). For the first period, however, high mortality offset growth and resulted in net losses on all cuttings.

Growth of Individual Trees

The growth of individual reserve sawtimber trees by diameter class, vigor class, species, and intensity of cutting was analyzed by covariance methods. Although linear regression was used in this analysis, it is not presumed that such a relationship would hold if a greater range of diameters were involved. Therefore, the results should not be projected for trees larger than 28 inches in diameter.

Differences in adjusted mean 20-year board-foot growth by diameter classes were not significant between immature and mature age groups for either ponderosa pine or Douglas-fir within the respective cuttings. Immature trees were generally about 120 years old, while mature trees

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[5/] Evenden, James C. An instance of insect damage resulting from zero-margin selective cutting of ponderosa pine. North. Rocky Mtn. Forest and Range Expt. Sta., Applied Forestry Note 84, 4 pp. 1938.

were about 220 years. Evidently for both species the growth potential for trees within this age range is similar.

Because of no real difference between the two broad age groups all trees of a given species were combined into one age group and sorted by vigor classes. The regressions of 20-year growth on diameter were then tested by three vigor classes: good, fair, and poor. Correlation coefficients for all regressions were significant. By presenting the results in general vigor terms they may be interpreted for the several tree classification systems in use.

Board-foot growth for 120- to 220-year-old trees of both species by initial diameter and vigor was greater on the medium than on the light cutting as shown in table 2. Among the factors accounting for the better growth in the medium cutting are greater growing space and a higher percentage of trees in the better-vigor classes. Greater growing space proved to be the major factor. Reserve trees had more growing space where 78 percent of the volume was cut than where 41 percent was cut and they responded accordingly. For example, a 20-inch good-vigor ponderosa pine grew 175 board feet in 20 years on the medium cutting compared with 99 board feet on the light cutting.

Growth of both ponderosa pine and Douglas-fir good-vigor trees was not significantly different from the growth of fair-vigor trees on the medium cutting. Therefore, the data for the two vigor classes were combined in a single regression to compute the values recorded in table 2. On this cutting there were insufficient poor-vigor trees to include in the analysis.

Under the greater competition existing on the light cutting, trees of both species grew according to vigor (table 2). The adjusted mean growth of good-vigor trees significantly surpassed that of the fair trees, and fair trees in turn surpassed poor-vigor trees. However, with increased size the trend of growth was toward equality between good- and fair-vigor classes. Growth of poor-vigor trees was consistently lower in all sizes.

CONCLUSIONS

The specific growth values reported here, of course, are applicable only to partial cuttings in similar stands under like conditions. However, certain growth relationships such as differential response by vigor classes dependent on growing space may have broader application.

Table 2.--Individual tree growth in 20 years by species, initial diameter, vigor, and intensity of cutting (120- to 220-year-old trees)

Initial D.B.H.	Ponderosa pine vigor class			Douglas-fir vigor class		
	Good	Fair	Poor	Good	Fair	Poor
(Inches)	Board feet			Board feet		
	Medium cutting (78 percent)1/					
12	69	(2/)	(3/)	70	(2/)	(3/)
16	122			104		
20	175			137		
24	228			171		
28	282			205		
	Light cutting (41 percent)					
12	55	30	19	60	41	32
16	77	58	35	74	58	40
20	99	86	52	87	75	48
24	121	114	68	101	92	56
28	143	142	85	115	109	63

1/ Trees on the heavy cutting responded similarly but were insufficient in number in the several vigor classes for complete analysis.

2/ Values are the same as for good vigor.

3/ Insufficient data.

This study suggests that substantial board-foot growth after the first cut may be realized by:

1. Reserving from 4,000 to 8,000 board feet per acre of good- or fair-vigor, 120- to 220-year-old sawtimber. Trees should be of moderate size and be provided with ample growing space. A reserve within this range should result in both high board-foot increment and reasonable growth percentage increase.

2. Releasing and protecting young trees just under merchantable size from damage in order to realize maximum ingrowth.

3. Minimizing future mortality to insure highest possible net growth. Bark beetles may increase to destructive numbers in large tops and cull material, so closer utilization or burning or scorching this material during slash disposal should be employed. Removing trees susceptible to windthrow will also decrease mortality losses.

4. Retaining ponderosa pine in preference to Douglas-fir wherever possible because of greater growth per tree for a given size.